A SAFETY ARRANGEMENT

THE PRESENT INVENTION relates to a safety arrangement and more particularly relates to a safety arrangement to provide protection for a passenger in a motor vehicle.

It has been proposed to provide an air-bag located in front of a passenger in a motor vehicle, the air-bag being arranged to be inflated in case of an impact involving the vehicle to provide protection for the occupant.

It is known that whilst such an air-bag may provide good protection for a seat occupant who, at the instant of impact, is sitting in an "ordinary" position, nevertheless, the air-bag may actually injure a seat occupant who, at the moment of impact, is not in the ordinary position, but, instead, is leaning forwards, for example to gain access to a glove box.

It has been proposed that an arrangement should be provided to detect when a vehicle occupant is out of the ordinary position and to moderate inflation of the air-bag, or even inhibit inflation of the air-bag, in such a situation, in order to reduce the risk of the air-bag itself injuring the occupant.

Various proposals have been made previously concerning detectors to detect when a vehicle occupant is out of position. Suggestions have been made involving the use of capacitative sensors, the electric capacity of such sensors

depending upon the proximity of various parts of the occupant. It has also been proposed to use various sensors which use transmitted waves, such as infrared or ultrasonic sensors, with the sensors being used in the manner of a radar or "echo sounder" to determine the position of the occupant. Such sensors are expensive, or complicated, or unreliable.

It has also been proposed to utilise a sensor which determines the length of safety belt, as worn by the vehicle occupant, that has been withdrawn from the retractor on which the safety belt is initially stored. However, even a sensor of this types doe not, of itself, provide a reliable indication of the position of the occupant.

The present invention seeks to provide an improved safety device.

According one aspect of this invention there is provided a safety arrangement for detecting the position of an occupant of a seat in a motor vehicle, the seat being provided with a safety belt and an associated retractor for use by the occupant of the seat, there being a sensor for measuring a parameter corresponding to the length of belt withdrawn from the retractor relative to a predetermined reference value, the safety arrangement also incorporating a seat position sensor and a processor unit to process signals from the two sensors to evaluate the position of the seat occupant, wherein the safety belt system incorporates a buckle, the buckle being provided with a sensor to indicate when the safety belt is buckled in position, the predetermined reference value being the minimum belt length remaining withdrawn from the retractor after the belt has been buckled up.

Preferably the processor unit utilises signals from the seat position sensor to determine the ordinary position of the front part of the chest bone of a

seat occupant relative to an air-bag, that position corresponding to the predetermined reference value of belt length.

According to another aspect of this invention there is provided a safety arrangement for detecting the position of an occupant of a seat in a motor vehicle having a fixed position, the seat being provided with a safety belt and an associated retractor for use by the occupant of the seat, there being a sensor for measuring a parameter corresponding to the length of belt withdrawn from the retractor relative to a predetermined reference value, the safety arrangement also incorporating a processor unit to process signals from the sensor to evaluate the position of the seat occupant, wherein the safety belt system incorporates a buckle, the buckle being provided with a sensor to indicate when the safety belt is buckled in position, the predetermined reference value being the minimum belt length remaining withdrawn from the retractor after the belt has been buckled up.

Preferably the processor unit, based on the position of the seat, determines the ordinary position of the front part of the chest bone of a seat occupant relative to an air-bag, that position corresponding to the predetermined reference value of belt length.

Conveniently the reference valve is continuously or repeatedly updated, and a new reference valve is stored whenever a new minimum belt length meaning withdrawing from the retractor, which is less than the current minimum length, is determined.

Advantageously a measured change in the length of the belt withdrawn from the retractor, relative to the predetermined reference value is utilised, by the processor unit, to estimate the longitudinal change in position of the front part of the chest bone of the seat occupant.

Preferably the parameter that is measured is the extent of the angular rotation of the spool of the retractor.

In one embodiment the processor unit is connected to control the performance of a load-limiter for the safety-belt.

In a preferred embodiment the processor unit is connected to an air-bag unit positioned in front of the vehicle seat to control the mode of performance of the air-bag.

Conveniently the processor unit modifies the venting of the air-bag.

Alternatively the processor unit moderates deployment of the air-bag.

Alternatively again the processor unit inhibits deployment of the air-bag.

Preferably the processor unit is configured to determine a new reference value whenever the seat is moved after the predetermined reference value has been determined.

Advantageously the new reference value is determined by determining the minimum length of belt withdrawn from the retractor after the seat is moved, the processor being configured to process signals corresponding to the new minimum belt length and the new position of the seat.

Preferably the new reference value is determined by determining the change in the position of the seat and modifying the original predetermined reference value.

Conveniently the reference value is modified by a value corresponding to the distance of, and the direction of, the change in position of the seat.

Conveniently subsequently a new reference value is determined by determining the minimum length of belt withdrawn from the retractor and the position of the seat.

In order that the invention may be more readily understood, and so that further features thereof may be appreciated, the invention will now be described, by way of example, with reference to the accompanying drawings in which:

FIGURE 1 is partly a side view of a vehicle seat illustrating the seat occupant and partly a diagrammatic view of integers of the present invention;

FIGURE 2 is a view corresponding to Figure 1 indicating various positions and parameters as used in a mathematical analysis that forms part of the following description;

FIGURE 3 is a graphical figure for purposes of explanation; and

FIGURE 4 is a further graphical figure.

Looking initially at Figure 1 of the accompanying drawings a seat 1 in a motor vehicle is illustrated, the seat having a squab 2 and a back rest 3. The seat occupant 4 is indicated, the seat occupant having an ordinary position shown in generally solid lines and a leaning forward or "out of ordinary position" shown in phantom.

The seat 1 is mounted on a carriage 5, the carriage 5 being moveable along a track 6 which is secured in position to the floor of the vehicle. A sensor 7 is provided which senses the position of the carriage 5 relative to the track 6. The output of the sensor 7 is forwarded to a central processor unit 8.

A seat-belt 9 is provided which is associated with the seat 1. The seat-belt 9 is initially stored within a retractor 10. The retractor 10 is provided with a measuring mechanism 11 to measure the amount of seat-belt withdrawn from the retractor. The mechanism may take many forms and may, for example, be a mechanism which actually measures the length of belt paid out using a rotating measuring wheel or the like which engages the belt, or may include a mechanism which measures the diameter of the safety belt remaining wound on the spool of the retractor mechanism.

However, a preferred arrangement includes an optical sensor, the optical sensor being located adjacent a plurality of axially extending alternating segments of different colour which extend as a band around part of the spool of the retractor. As the spool winds in and out, so the different coloured bands pass adjacent the sensor, and the sensor can sense the presence of the bands and the direction of movement of the bands. Thus the sensor can provide signals to the central processor unit 8, the central processor unit 8 being able to determine the extent of angular rotation of the spool, thus being able to determine the amount of safety belt that is retracted into the spool and/or paid out from the spool. Alternatively axially or radially extending magnetic strips could be utilised, in conjunction with a sensor such as a Hall effect sensor.

The retractor 10 may incorporate a load-limiter. The load-limiter may operate to pay-out a length of belt, if the force in the belt exceeds a limit, while absorbing energy. Various types of load-limiter which operate in this way have been proposed before. The load-limiter may be a controlled load-limiter.

The safety belt 9 is provided with a tongue 12, the tongue 12 being releasably received within a buckle 13. The buckle 13 is provided with a sensor mechanism to determine whether the tongue 12 is or is not engaged within the buckle 13. The mechanism sends an appropriate signal to the central processor unit 8. The free end of the safety belt 9 is provided with an anchorage 14 which is fixed to the chassis. The buckle 13 is located to one side of the vehicle seat and the anchorage 14 is located towards the other side of the vehicle seat, being the side of the vehicle seat where the retractor 10 is provided.

The safety belt 9, on emerging from the retractor 10 passes through a pillar loop guide 16 before passing over one shoulder of the seat occupant 4, the belt presenting a portion 17 which extends diagonally across the chest of the seat occupant 4, to the tongue 12, and further portion 18 which extends across the lap of the seat occupant to the anchorage 14.

An air-bag 19 is provided, the air-bag, in this embodiment, being mounted within the dashboard 20 of the motor vehicle. It is to be noted, however, that the air-bag may be mounted within a steering wheel if the seat occupant 4 is the driver of the motor vehicle.

The central processor unit 8 is provided to moderate or inhibit inflation of the air-bag 19 depending upon the position of the seat occupant 4, and/or to control a load-limiter associated with the safety-belt. The load-limiter will allow some seat-belt to be paid-out, after the retractor has locked in an accident situation, with energy being absorbed. The load-limiter may be the load-limiter present within the retractor. If the seat occupant 4 is leaning forwardly, as shown in phantom in Figure 2, so that the distance between the chest of the seat occupant and the air-bag 19 (x_B-x_C) is below a predetermined minimum distance, then the air-bag 19 is only to be inflated in a relatively gentle manner,

so that the air-bag is only partially inflated, or inflation of the air-bag is to be totally inhibited. The danger from the air-bag is actually related to the position of the stiff, load-taking surface of the occupant, i.e. the chest or rather the chest bone relative to the air-bag housing before the air-bag is inflated. The less the distance between the chest bone and the air-bag housing, the greater the danger, unless the operation of the air-bag is modified. The operation of the air-bag may be optimised in dependence on the position of the chest bone relative to the air-bag housing initially containing the air-bag.

It is to be appreciated that the central processor unit 8 is initially provided, from the sensor 7, with a signal that is indicative of the position of the seat 1 relative to the air-bag 19. When the seat occupant 4 initially occupies the seat, the seat-belt is in a fully retracted initial position. As the seat occupant becomes belted into the seat, a length of safety belt is withdrawn as the seat-belt is moved to the position illustrated in Figure 1 with the tongue 12 mounted within the buckle 13. The central processor unit receives a signal as the tongue 12 is received in the buckle 13. However, as the seat occupant occupies the ordinary position leaning backward, some seat-belt is retracted back into the retractor. The measuring mechanism 11, together with the central processor unit 8 may effectively monitor the length of the safety-belt withdrawn from the retractor relative a reference point, the reference point or reference value being set at the latest minimum length of belt withdrawn from the retractor after the tongue 12 has been engaged with the buckle 13. Thus the measuring mechanism will continuously or repeatedly determine the length of belt withdrawn from the retractor, and update a stored value representative of the minimum length, if a new minimum value, less than the current minimum value, is reached.

Should the seat occupant move the seat, after the seat belt has been buckled and the measuring mechanism is measured a value of the minimum

length of the belt withdrawn to the tractor when the occupant is in the ordinary position, the central processor unit determines a new reference point or reference value, by adjusting the original reference point or reference point to a an extent related to the amount and direction of the adjustment of the seat position.

The reference point or reference value for the minimum length of belt must correspond to a situation in which the seat occupant is in the ordinary position, sitting well back and not leaning forwardly. Assuming that the thickness of the torso (distance between the rear surface of the back of the seat occupant and the front surface of the chest bone) of a vehicle occupant is substantially the same for all vehicle occupants, it is possible, to determine the position of the front part of the chest (chest bone) of the seat occupant relative to the air-bag, when the occupant is in the ordinary position, as this is dependent purely upon the position of the seat 1 as a consequence of the adjustment of the carriage 5 on the rails 6. The measured minimum length of belt withdrawn from the retractor corresponds with this position of the chest (chest bone) of the seat occupant.

Should the seat occupant move forwardly, to the position shown in phantom in Figure 1, a further length of safety belt will be paid out, and the extent of paying out of the safety belt beyond the minimum length will be indicative of the degree of forward movement of the seat occupant from the "ordinary" position. Consequently, by determining the amount of seat-belt paid out in excess of the minimum amount, and by taking into account the position of the seat 1, it is possible for the central processor unit 8 to determine, at least to a first approximation, the position of the front part of the chest (chest bone) of the seat occupant 4, and to moderate or inhibit deployment of the air-bag 19 appropriately.

It is possible that in an enhanced embodiment of the invention the angle of rake of the backrest of the seat would also be taken into account. In such an embodiment a sensor will sense the degree of rake of the backrest and pass an appropriate signal to the central processor unit 8.

Turning now to Figure 2, the essential structural features of the safety arrangement are shown, although the central processor unit, for the sake of clarity of illustration, has been omitted. A x axis is shown, the axis being marked with various reference points.

x_S is positioned at the backrest of the seat. x_C is the position of the chest (chest bone) of the seat occupant, the chest (chest bone) having an ordinary position $x_{C\ min}$, when the seat occupant is in the ordinary position and having a current position x_C, which could be as shown in the forward position.

x_D relates to the position of the diagonal part 17 of the seat-belt. This is slightly in front of the position of the chest (chest bone) of the seat occupant due to the thickness of the clothing worn by the seat occupant (and soft body tissues in front of the chest bone). x_B shows the position of the air-bag cover which, in the illustrated embodiment, is the dashboard 20.

The seat-belt 19 has three portions of varying length. The portion of the seat-belt 9 which extends from the retractor 10 to the pillar loop 16 is of a fixed length. The first portion of variable length extends from the pillar loop 16 to a point adjacent the shoulder of the seat occupant in line with the seat back. This is the distance l_S as shown in Figure 2, and corresponds to the distance between the original of the x axis and the point x_S which relates to the seat back. Thus the distance l_S is dependent upon the position of the seat as adjusted along the rail 6.

The second portion of seat-belt of variable length is the diagonal portion which extends to the tongue 12, being the seat-belt portion 17. This portion has a length l_D. The length of this portion of the seat-belt varies with the thickness of the chest (chest bone), d_c, the thickness of clothing or jacket worn by the seat occupant d_j and the degree of leaning forward of the seat occupant d_f.

The third position is the lap belt, having the length l_L.

It is to be understood that:

$$x_{Dmin} - x_{Cmin} = x_D - x_C = d_j;\ x_{Cmin} - x_S = d_c;\ x_D - x_{Dmin} = d_f$$

The distance of importance, in determining whether the inflation of an air-bag should be modified or inhibited, is the distance between the chest (chest bone) and air-bag:

$$d_{CB} = x_B - x_C$$

The present invention is based on the understanding that the thickness of the torso to the front surface of the chest bone only varies a little between large persons and small persons. It has been found typically d_C is 20 +/- 3 cms. It can, therefore, be assumed that, to a first approximation, for any case d_C is 20 cms, and the appropriate calculation as to the distance between the front of the chest (chest bone) and the air-bag can be calculated on this assumption.

The distance d_{CB} *is a function of* x_C, as x_B is effectively constant.

At any moment the total variable length of the seat-belt l_T is:

$$l_T = l_S + l_D + l_L$$

$x_C - x_{Cmin} = x_D - x_{Dmin} = f(\Delta l),\ \Delta l = l_D - l_{Dmin}$

$x_{Cmin} = x_S + d_C = f(x_S)$, as d_C is assumed to be a constant

$x_S =$ is measured by the seat track sensor.

Thus $d_{CB} = f(x_C) = f(f(\Delta l) + x_{Cmin}) = f(f(\Delta l) + f(x_s)) = f(\Delta l, x_s)$

After the seat occupant has been buckled in position, the retractor 10 will tend to retract seat-belt, and a minimum value of l_T, a value of l_{Tmin} can be measured as follows:

$l_{Tmin} = l_S + l_{Dmin} + l_L$

l_S relates to x_S, the position of the seat and varies only when the seat is moved. l_L is related to the size of the hips or belly of the seat occupant and is fixed after the belt is buckled but can vary a lot between different occupants.

The value of l_{Tmin} can be stored as the reference value, and should the seat occupant further move forwards, l_D will increase, thus increasing the overall length of belt withdrawn. The increase in l_D is indicative of the degree of movement of the chest (chest bone) of the seat occupant forwardly of the ordinary position, and thus the parameter can be used to control deployment of the air-bag.

If the seat is moved forward after the belt is buckled, a new reference value has to be calculated, because the new relevant l_{Tmin} is bigger than the old one. This could be done by using the latest l_{min} after that the seat has been moved, but a relevant reference could be determined more quickly by calculating a new reference as $l_{min\ new} = l_{min\ old} + \Delta\ l_s \approx l_{min\ old} + \Delta x_s$, Δx_s being the change in seat position. This is true, if l_s is almost parallel with the seat track.

However, if the belt length is estimated by measuring the angle of the retractor spool, you have to know the function $l = \mathrm{f}(\alpha)$. See Figure 3.

Because this is not a linear function, $\Delta l \neq f(\Delta\alpha)$ but only $\Delta l \approx f(\Delta\alpha)$ within a limited range of α.

Also the reference value α_{min} is set after the belt is buckled. If the seat is moved after that, a new reference value could be calculated from the curves in Figure 4, showing α_{min} as a function of the seat position x_s. If the seat is moved forward the curve for a big occupant should be used and if it is moved rearward the curve for a small occupant should be used. This is to ensure that the real position of the occupant is not closer to the dashboard than the calculated position. If, for example, the seat is moved forward $\alpha_{min\ new} = \alpha_{min\ old} + \Delta\alpha_{big}$ where $\Delta\alpha_{big} = f(x_{sold}, x_{snew})$, according to the curve for a big occupant. x_{sold} is the old position of the seat and x_{snew} is the new position. Gradually when the occupant has reached the ordinary leaning back position, the reference value will be corrected.

However, $\Delta l = f(\Delta\alpha, \alpha)$. Thus the accuracy could be improved if a measurement is effected relative an absolute fixed reference (that does not change with size of occupant and position of seat).

The invention is based on the idea of detecting the position of the occupant from the amount of belt withdrawn relative a reference, if the position of the seat is known. This means that if the seat is fixed, like normally rear seats are, a seat position sensor is not needed.

When used in this Specification and Claims, the terms "comprises" and "comprising" and variations thereof mean that the specified features, steps or integers are included. The terms are not to be interpreted to exclude the presence of other features, steps or components.